Vehicle-Tank Metering Systems Operation & Design

Vehicle-Tank Meters

NIST Short Course

Objectives

- Identify key elements of VTM liquid- measuring device systems
- Describe principle of “Positive Displacement” liquid measuring

Vehicle-Tank Metering Systems

- Variety of designs of VTM LMD's
  - new technology & advances
- Intended to help you understand **typical** features, not specific makes and models
- Accuracy depends on the operation of the **whole system**, not just on the meter itself
- Will look at:
  - intake line
  - measuring and indicating elements
  - discharge elements
  - control elements

Figure 2-1:
The Vehicle-Tank Metering System

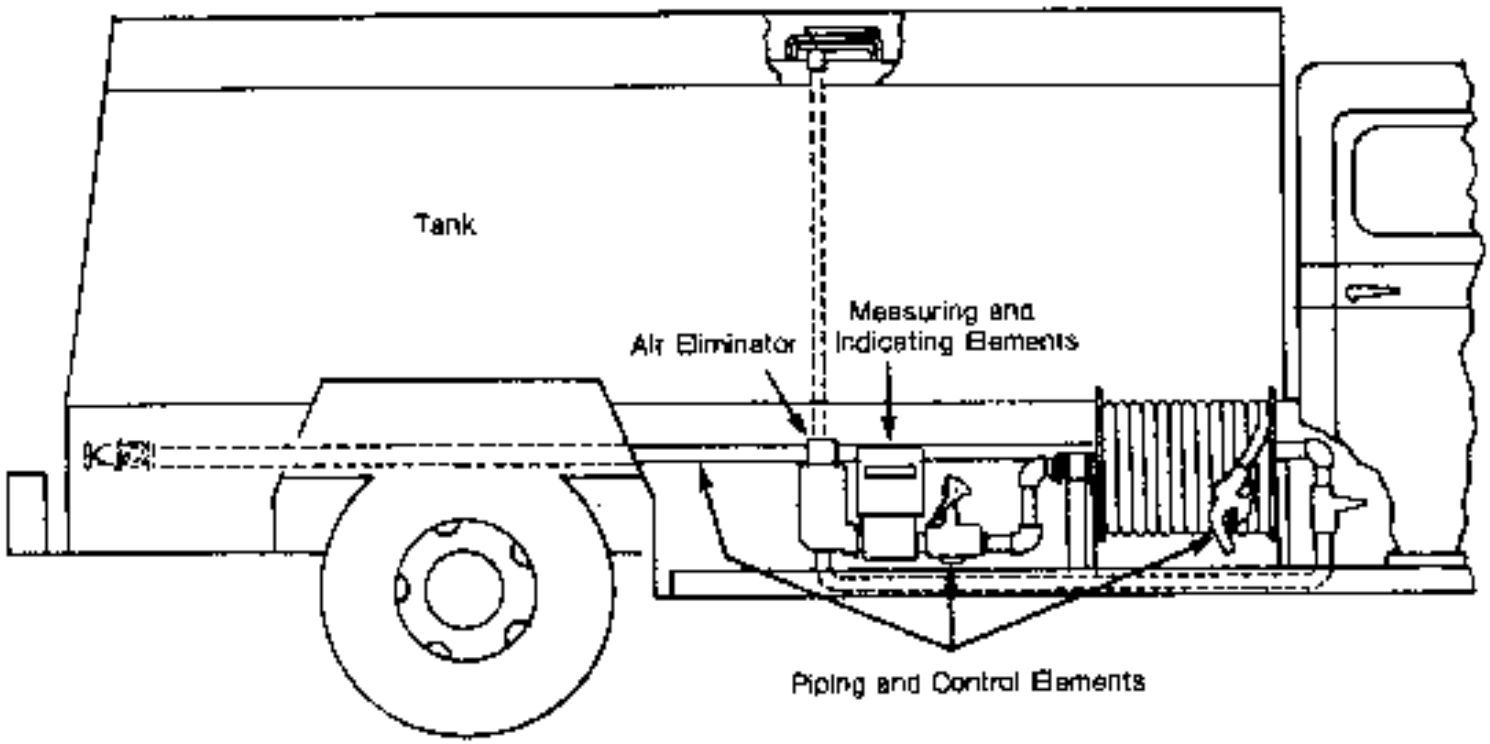
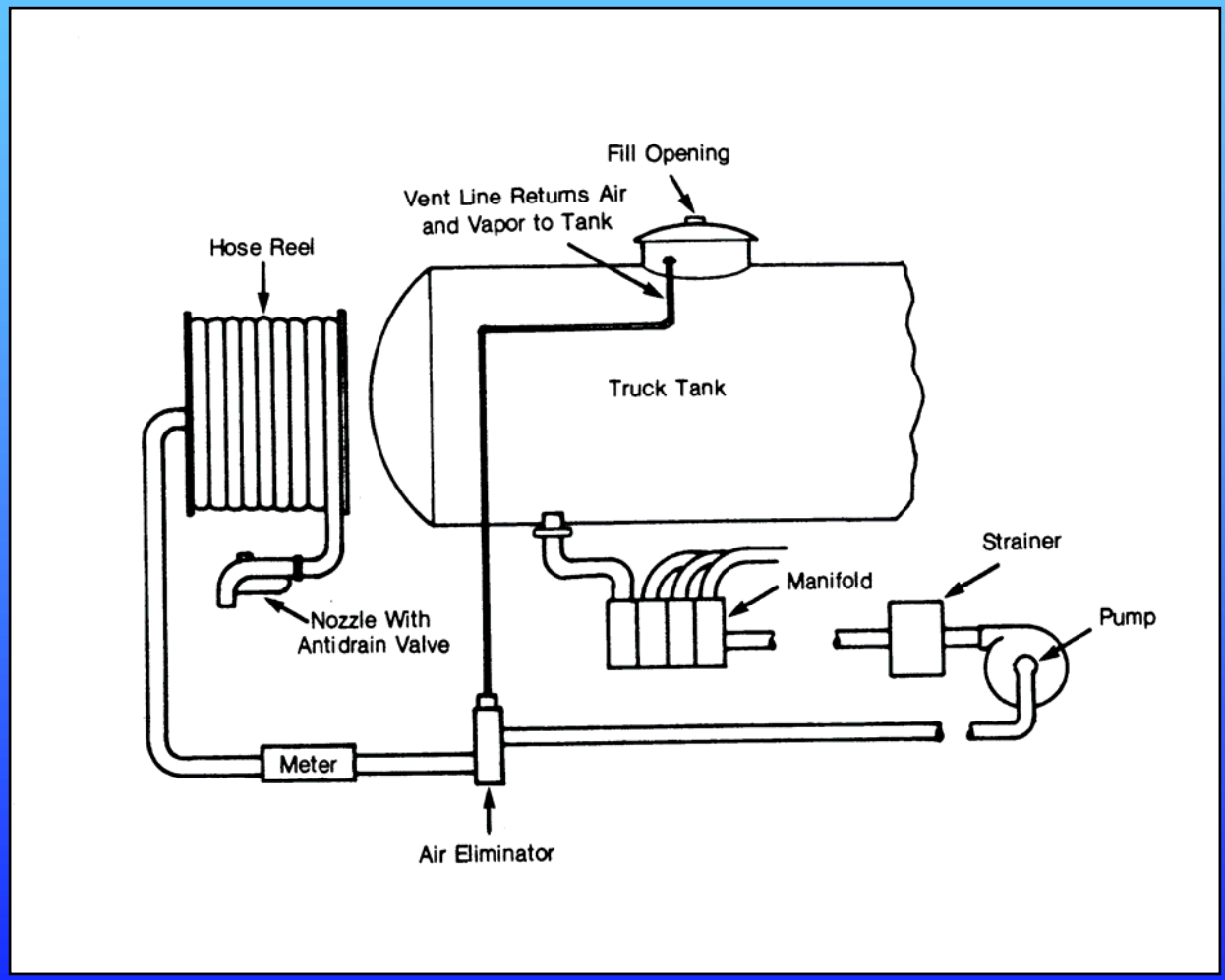
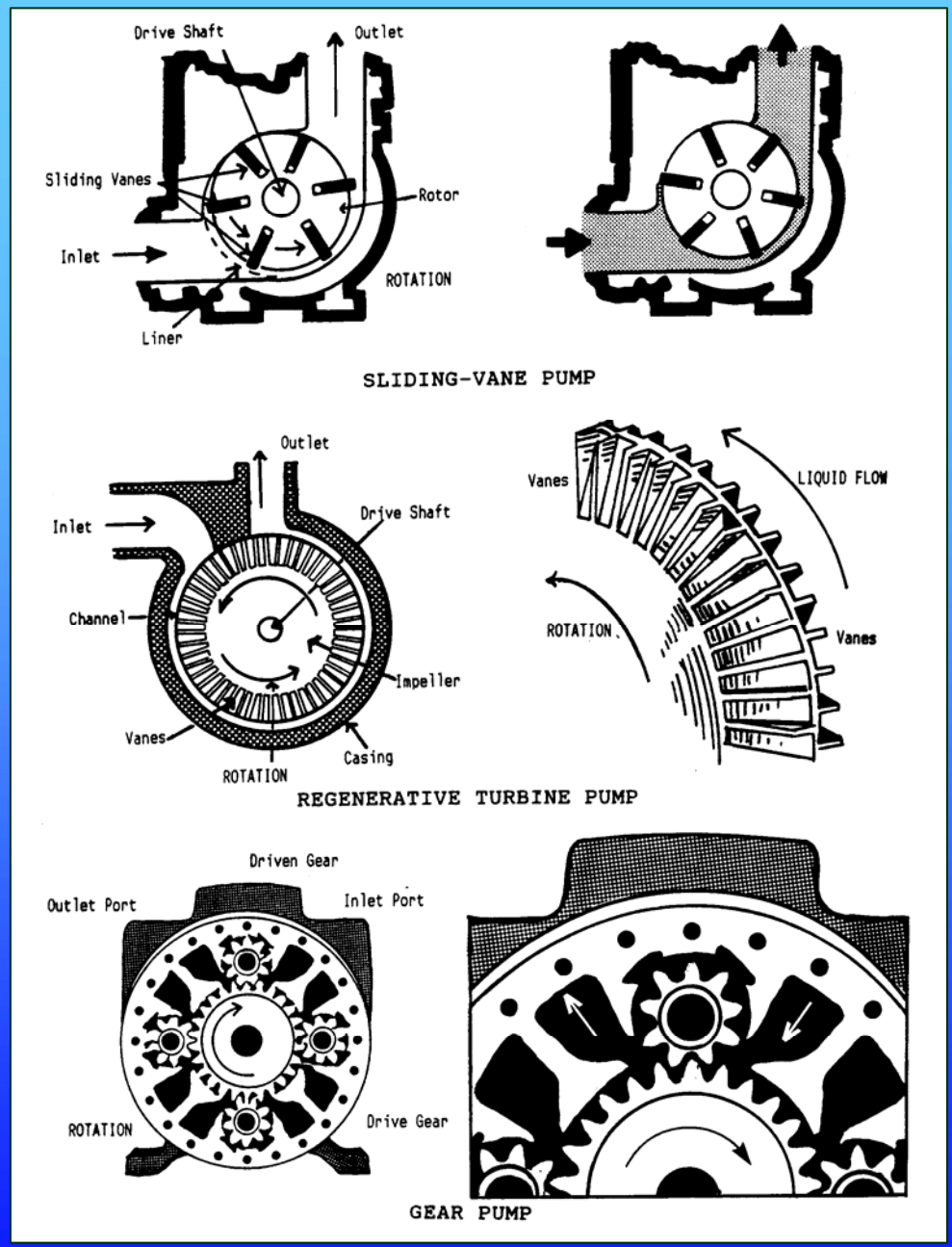


Figure 2-3: Power-Operated System



Typical Pump Designs



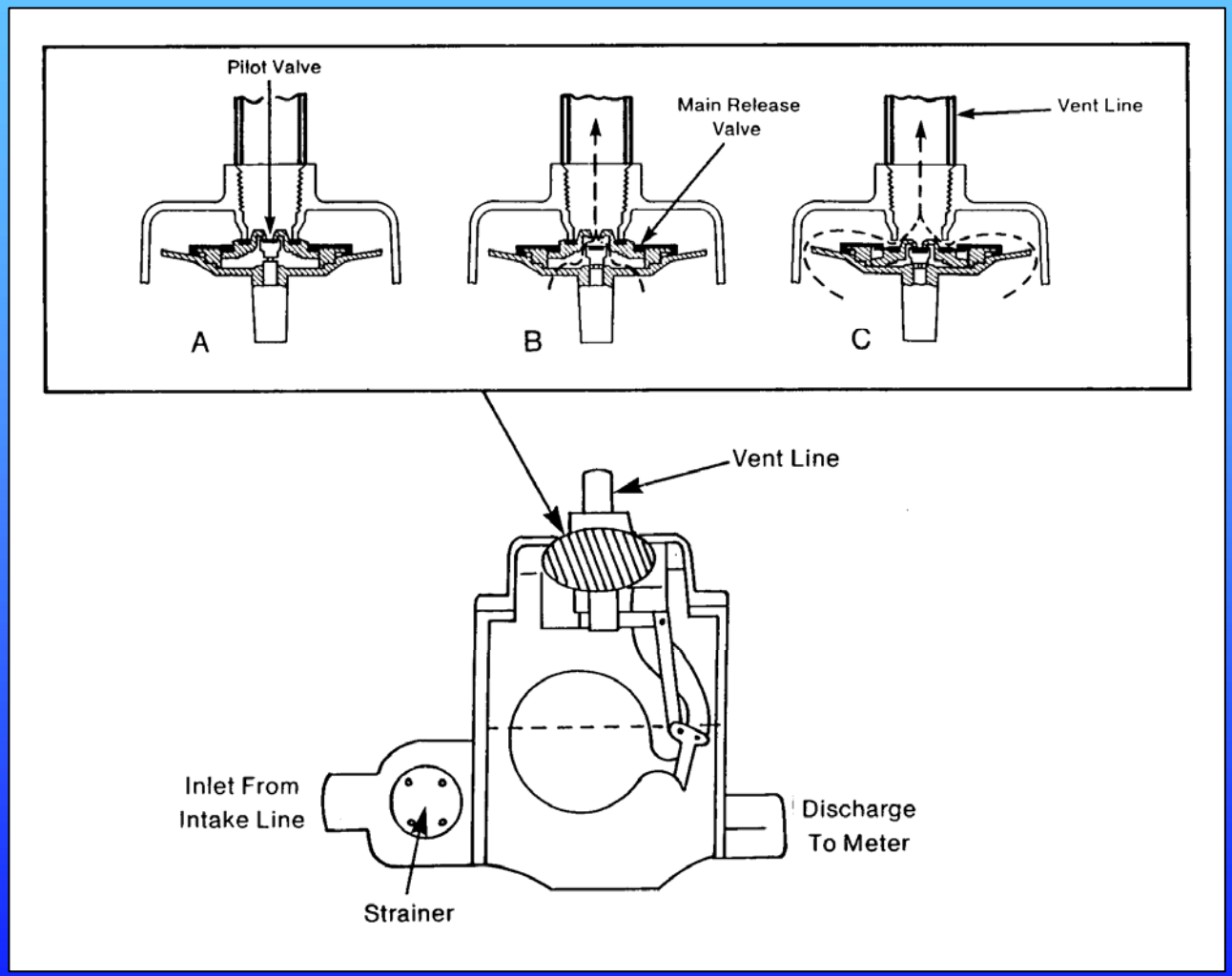
Pump Operation

- Pump draws product from tank and propels it toward meter
  - provides pressure required to deliver product
- usually driven by truck engine through linkage controlled by operator
- rate of displacement is a function of:
  - size of the piping at the outlet
  - pump speed and design

Pump Speed

- can be a critical element in measurement accuracy
- if too high, pressure at the inlet falls below the vapor pressure of the product
  - causes some vaporization
- technical term for this vaporization is **“cavitation”**
  - often called “flashing”
  - results in some degree of overregistration
  - right size and speed of pump help avoid “cavitation”

Typical Vapor Eliminator



Vapor Eliminator--Functions

- removes vapor prior to the meter
- last line of defense against vapor caused by restrictions, etc.
- Basic operation
  - float in chamber of air eliminator
  - liquid flows into chamber and vapor bubbles rise to the surface
  - when float drops below a certain level, valve opens to vent vapor
    - vapor carried back to vapor space of storage tank
  - as vapor is removed, level of liquid flowing in rises & valve closes
  - cycle begins again
- **entrained** air very difficult to remove

Other System Components

Strainers

- trap solid contaminants
- must be kept clean to avoid restrictions & vapor production

Piping and Valves

- suitable length of piping & proper fittings
  - reduces friction
    - reduces cavitation

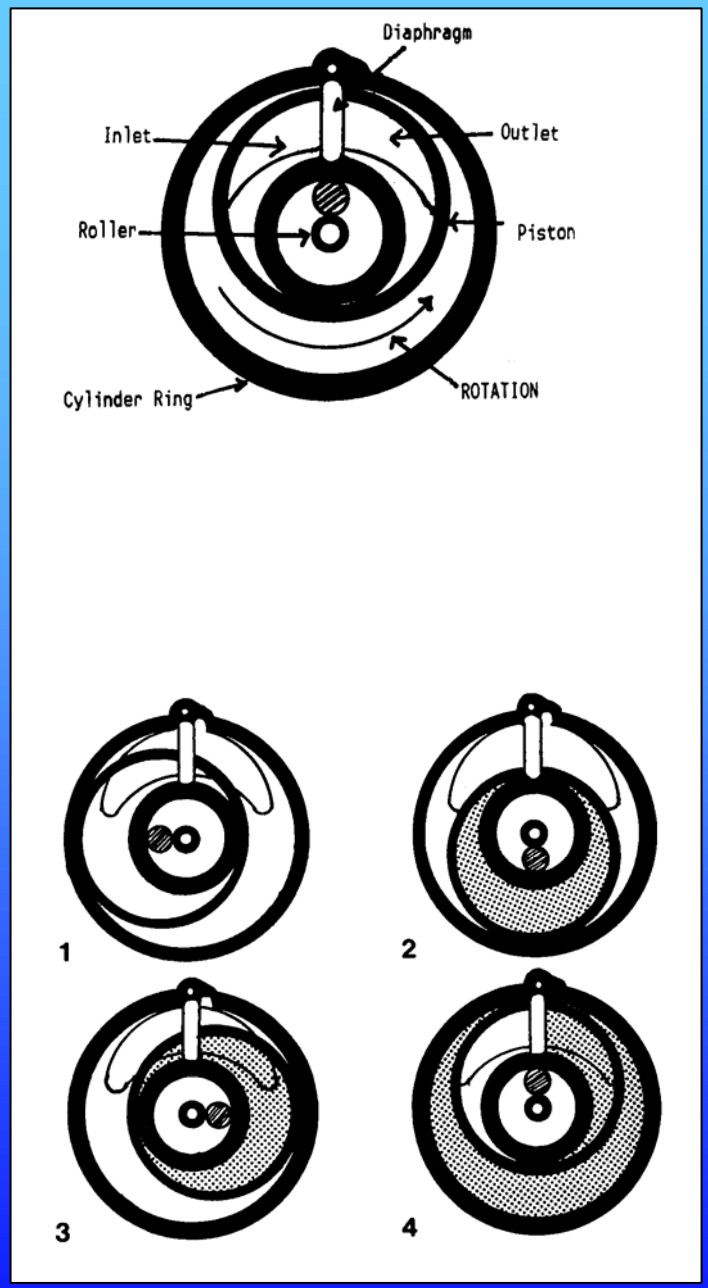
Positive Displacement Meters

- liquid momentarily separated into segments of known volume
- same number of segments pass through meter on each revolution
- segments are rejoined after the meter and flow to the discharge line
- fluid flow drives meter's moving parts
- volume is determined from number of meter revolutions & the quantity per revolution

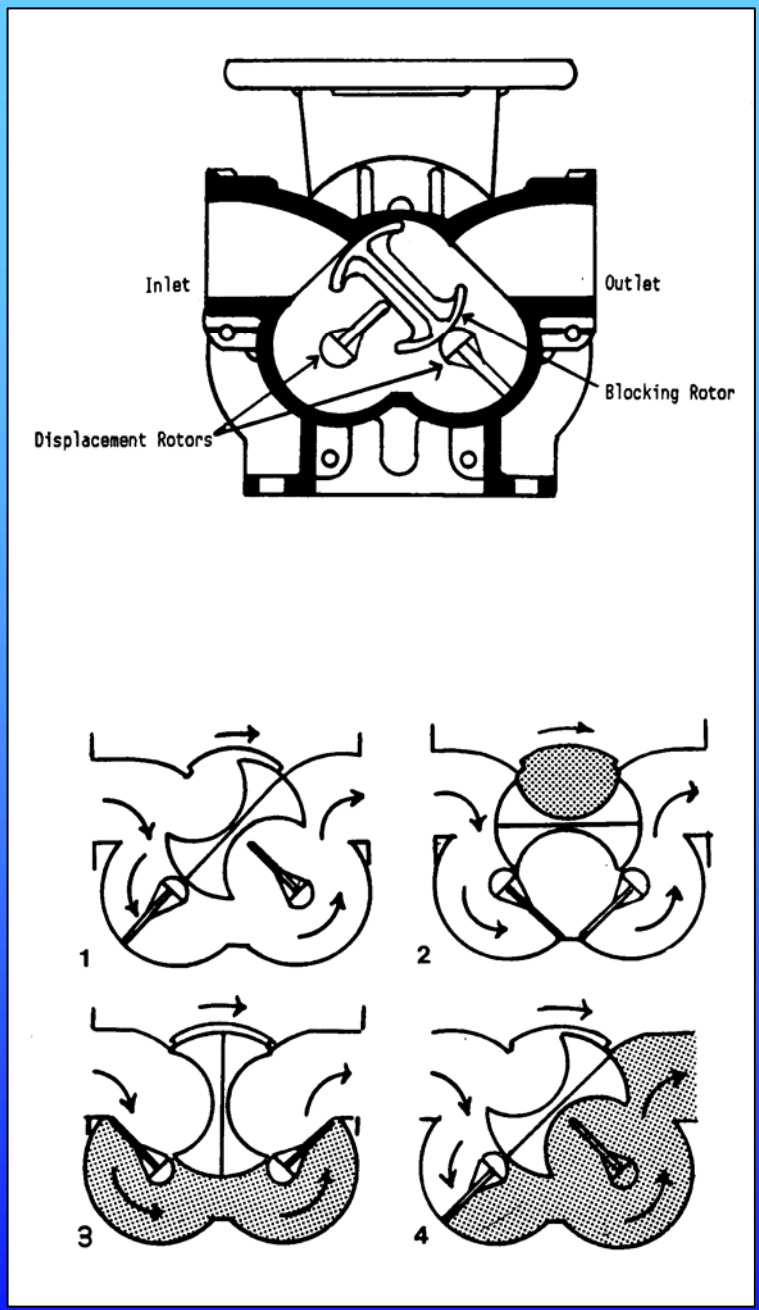
Other Metering Technologies

- Turbine
- Mass Flow
- Other

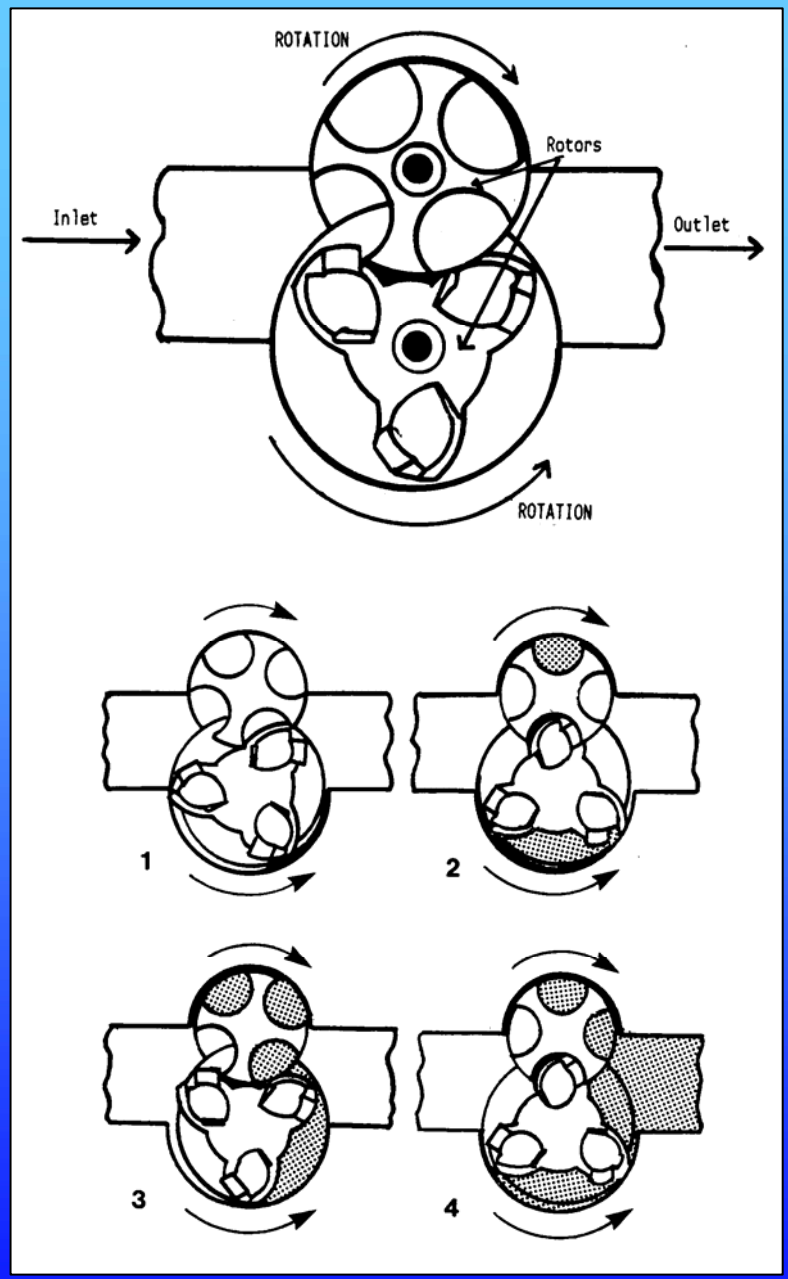
PD Meter Design - Example 1



PD Meter Design - Example 2



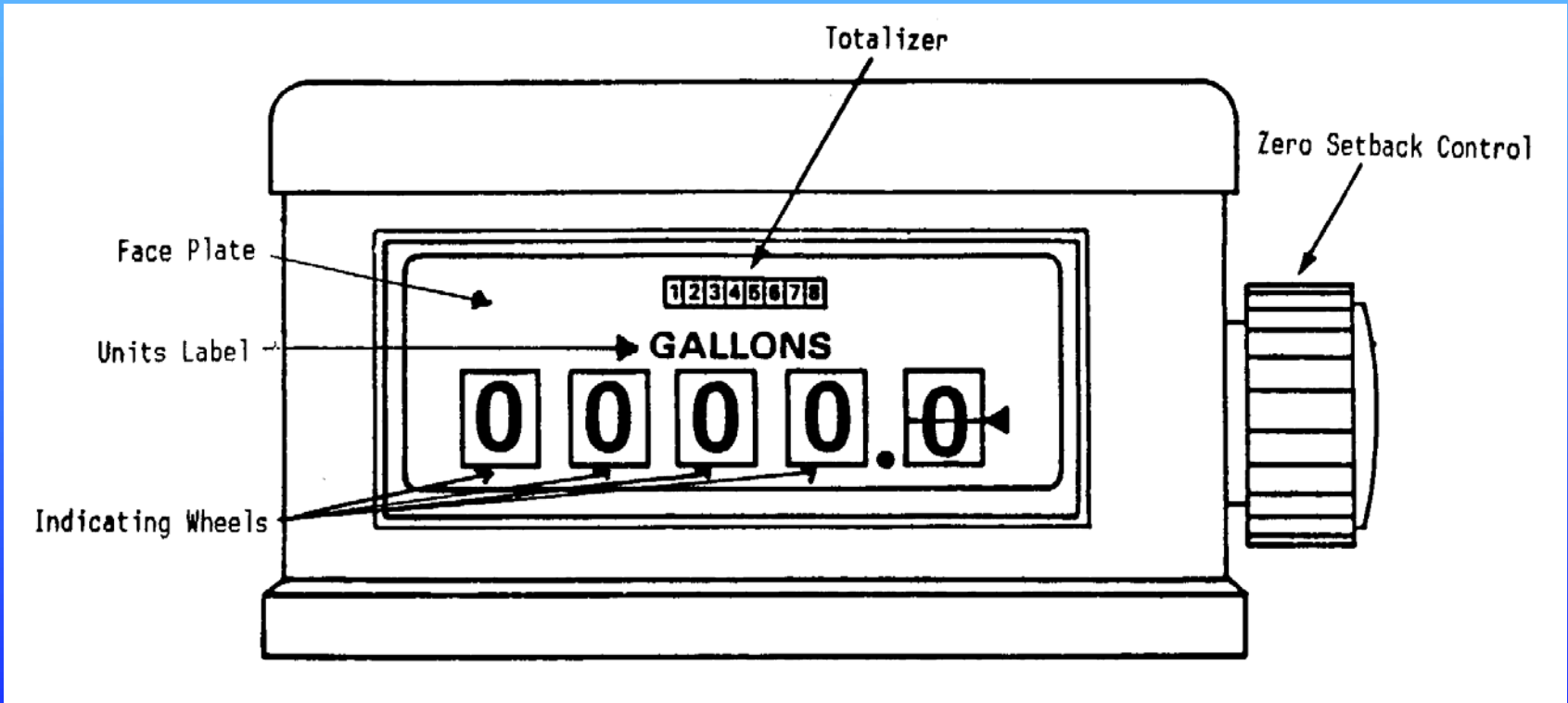
PD Meter Design - Example 3



Meter Errors

- simple design means relatively few causes
- typical causes:
  - presence of vapor in product
  - solid contaminants
    - widens clearances
    - this is why strainer is important
  - small amounts of slippage
    - can be offset by meter adjustment to some extent
    - increased at low flow rates

Figure 3-8:
Mechanical Indicator



Mechanical Registers

- wheel type:
  - series of wheels
  - one wheel per digit
  - wheel segmented with numbers & lines
  - revolving meter shaft
- gear train transfers revolution of meter to the indicating elements (to right-hand wheel)
- right-hand wheel turns with meter shaft
- each complete revolution of right-hand wheel increments next higher wheel
- fixed indicator--pointer

Figure 3-7:
Right Hand Indicating Wheel

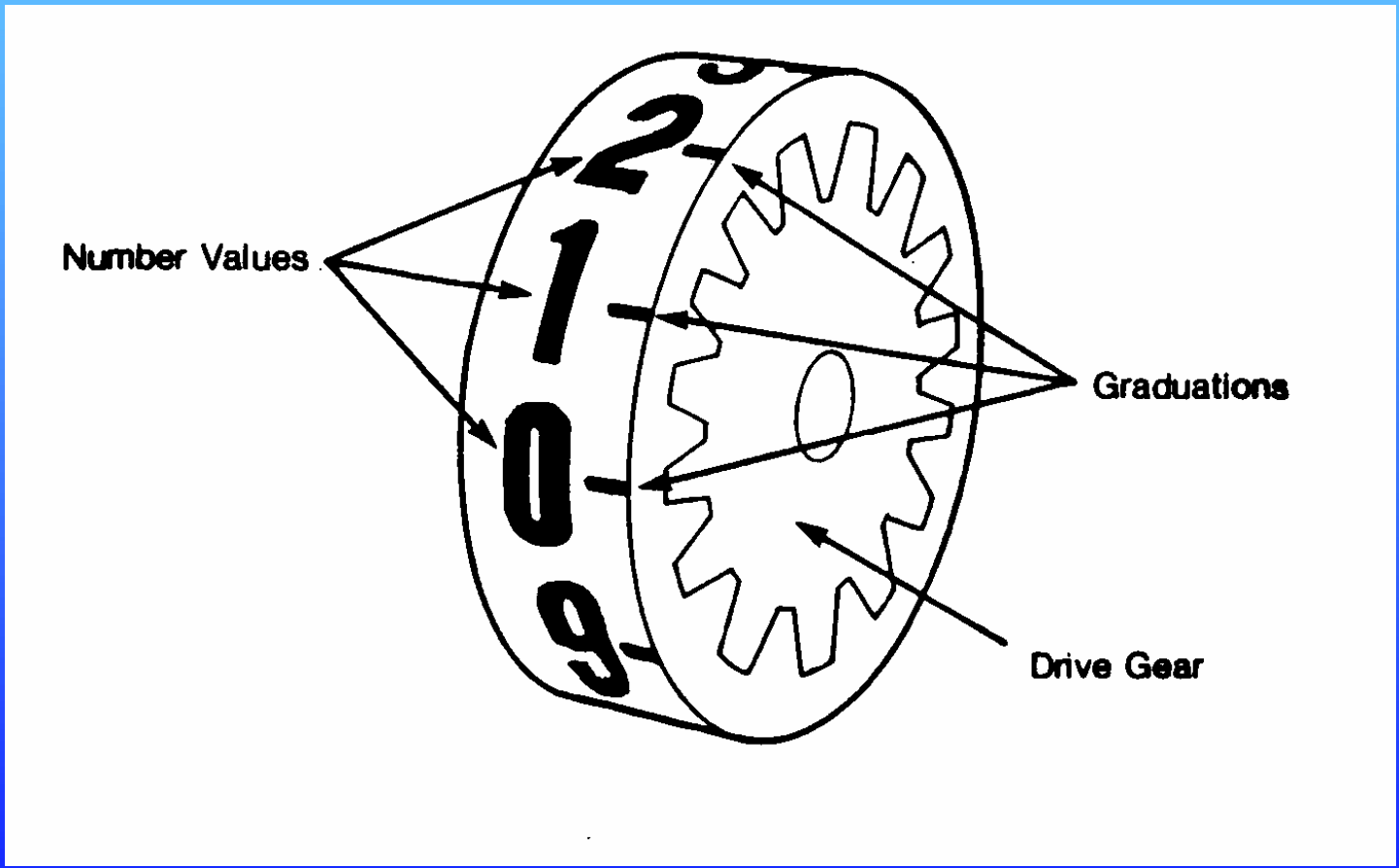
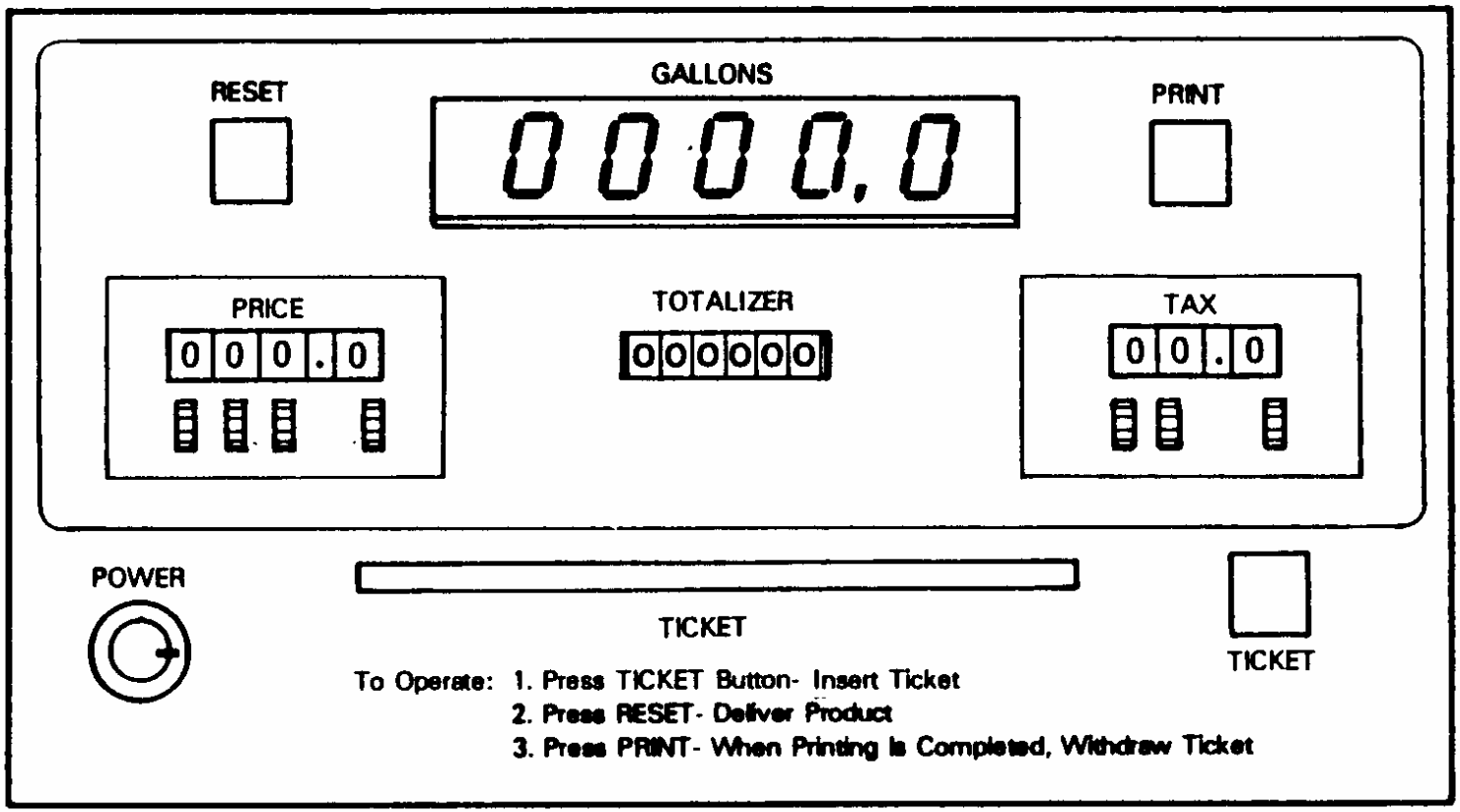


Figure 3-12:
Electronic Indicator



Electronic Indicators

- fewer moving parts
- often more features and information:
  - computing capability
  - multiple calibration points
  - data communication
- mechanical motion of the shaft is transferred into a digital signal
- accomplished by means of a pulser

Pulsers for Electronic Indicators

- different kinds of pulsers
- switch closed--current flows;
  switch open--current stops
- pulser can produce from 10 to 1,000 discrete pulses per revolution of the meter
- register counts the pulses and produce digital display

Definition - Analog Type

Analog:

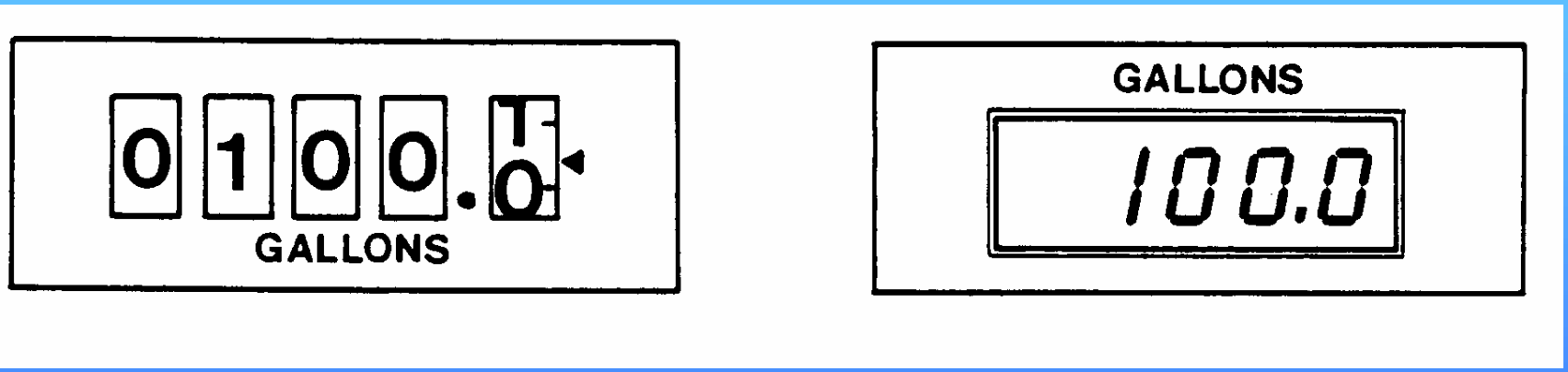
analog type. A system of indication or recording in which values are presented as a series of graduations in combination with an indicator, or in which the most sensitive element of an indicating system moves continuously during the operation of the device. [1.10]

Definition - Digital Type

Digital:

digital type. A system of indication or recording of the selector type or one that advances intermittently in which all values are presented digitally, or in numbers. In a digital indicating or recording element, or in digital representation, there are no graduations. [1.10]

Figure 3-11: Electronic and Digital Indicators

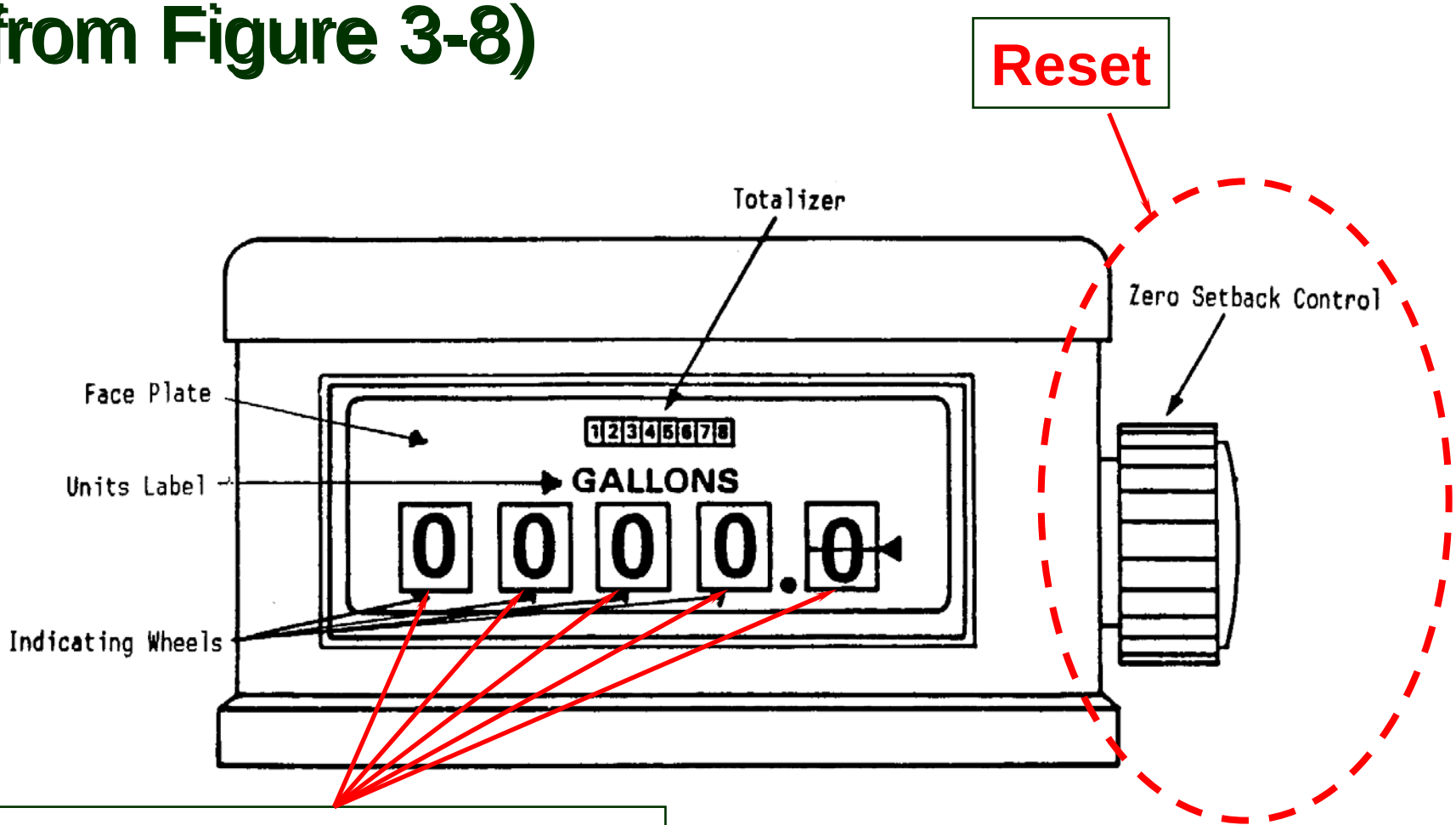


- analog shows quantities between graduations
- digital does **not** show intermediate quantities
- analog and digital can both be designed to meet the sensitivity required

Other Device Features - Reset

- returns indications to zero (per H44)
  - knob on an analog
  - pushbutton on a digital
- cannot display values during the reset operation when values advance to zero
  - do not want readable values during reset
  - shutters or blanking are used

Mechanical Indicator Reset (from Figure 3-8)

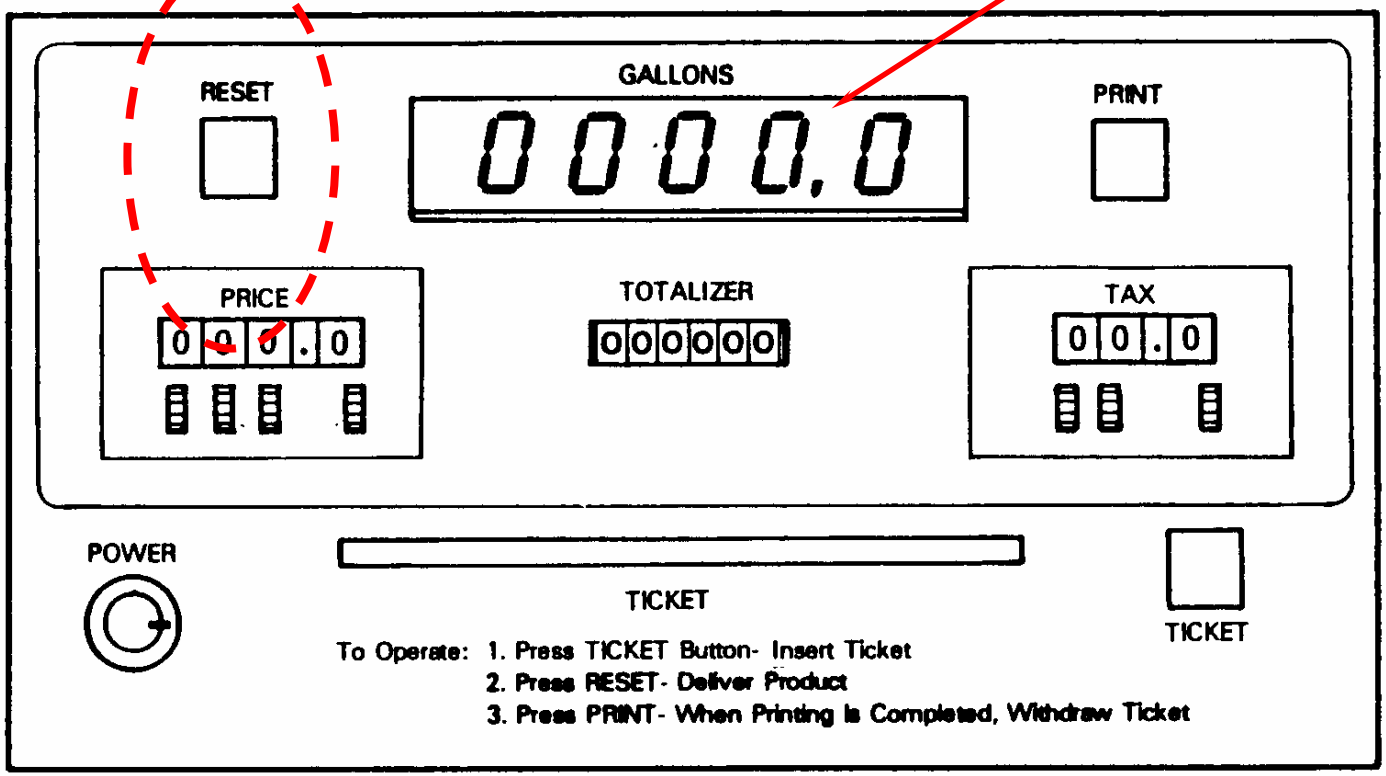


Shutters drop to obscure indications during reset

Electronic Indicator Reset (From Figure 3-12)

Reset

Indications blank during reset operation



Other Device Features - Totalizers

- totalizers keep track of total product
- used for:
  - inventory control
  - detect theft & loss
  - testing

Meter Adjustments Through the Indicator

- register “counts” number of meter revolutions
- can’t change quantity per revolution
  - so, change amount indicated per revolution
- register is adjusted to bring the indication of the delivery as close as possible to a zero-error condition
- excessively worn meter may not be capable of adjustment

Meter Adjustments (cont.)

Adjustments through digital indicators:

- performed electronically
- calibration factors based on errors observed during testing
- some have multiple point calibration

Adjustments through mechanical indicators:

- "change gear" mechanism in some models
  - rate of revolution is altered by changing gears
- another design adjusts the speed of the output shaft to the register over a range
  - may use a calibrated dial to accomplish this

Ticket Printer

- required for all vehicle-mounted systems (UR.2.2.)
  - requirement became retroactive in January 1994
  - exception for aircraft refueling & for aircraft-related operations (UR.2.2.1.)
- driven directly by the register:
  - mechanically or electronically
- some have capability to print prices, tax, dates, etc. calculated by the register

Discharge Line or Hose

- carries metered product to the receiving tank
- “wet hose” system
  - i.e. full of liquid at all times
  - shut-off valve at end to prevent hose from being drained
- “dry hose” system
  - designed to be drained after every delivery

Summary

I) A number of elements comprise VTM measuring systems

II) Intake Line

- Carries product from storage tank to the meter
- Includes:

a) system pump

b) several automatic and manual flow-controlling devices

c) vapor eliminator

d) strainers

e) valves

III) Meter

- most are positive displacement
- segment known volume of product

Summary

IV) Indicating Elements

- mechanical and electronic
- definitions: analog/digital
- reset
- totalizers
- meter errors are corrected by adjustments that affect the registration of product processed per meter cycle

V) Other accessory devices may be included

- ticket printer

VI) Discharge Line

VII) Additional Accessory Devices